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Information Sheet

COMMERCIAL PREPARATION AND FREEZING PRESERVATION OF SLICED APPLES

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Wartime restrictions on metals used in cans have resulted in a large increase in the quantity of sliced apples preserved by freezing for use in pies. About 15 million pounds were frozen for this purpose in 1942 and nearly 34 million pounds in 1943, in the United States. In the Western States about 1 million pounds were frozen in 1942 and nearly 20 million in 1943.

A prefreezing treatment is necessary to prevent the normal darkening that occurs in apple slices subsequent to defrosting. This darkening is due to enzymic oxidation and can be prevented by immersion of the slices in a solution of sulfurous acid or sodium bisulfite or by scalding in steam. The recommendations offered here are based on studies made in this Laboratory; the research work is being continued and additional reports will be made later. Since dipping in sodium bisulfite has proved superior to these other treatments, it is given special emphasis.

Preparation of Apple Slices

The apples are first peeled, cored, and sliced. Preparation can be carried out as a single operation on some machines, in which case the apple is left as a single spiral slice. More commonly only the peeling, coring, and trimming are done in one operation, and other equipment slices the apples either as rings or as longitudinal segments. With the latter type of slicing, cutting the apple into twelfths produces pieces of convenient size for use in pies.

Dipping in Sulfurous Acid

Sulfurous acid can be used in the prefreezing treatment of apple slices to prevent darkening. In fact, sulfurous acid will penetrate the pieces much more rapidly than a sodium bisulfite solution; however, it is not generally used because of its obnoxious odor, which is strong enough to be very disagreeable to the workers. Sodium bisulfite solution has the advantage of being almost odorless, and although it penetrates more slowly, it provides a practical medium for treatment.

Dipping in Sodium Bisulfite

Two types of equipment are commonly used for the sodium bisulfite treatment. One comprises a tank and a walking-beam conveyor that continuously removes the slices from the solution; the other comprises a tank and wicker baskets that are filled with slices and dipped by hand into the bisulfite solution. The walking-beam conveyor is commonly used by the dried-apple industry and the wicker baskets are used for the sulfurous acid (sulfur dioxide) or sodium bisulfite prefreezing treatment of apricots and peaches. The wicker basket, known as the "Chinese basket," is used extensively by West Coast canners in blanching asparagus and has proved highly satisfactory.

If a walking-beam conveyor is used, a nearly square tank is required. If wicker baskets are used, a long narrow wooden vat constructed of planks is suitable. Such a vat, built of 2x12-inch planks, two planks wide, two deep, and 11 feet long, has a capacity of 2 or 3 tons an hour.

If the tank is equipped with a walking-beam conveyor, the slices are dropped directly from the slicers into the tank or on a conveyor belt that carries them directly to the tank. The wicker baskets, however, are nearly filled with the slices and then immersed in the dipping bath. The duration of the dip should be at least 1 minute. Tests have shown little advantage for a 5-minute dip, as compared with 1 minute, for apple slices.

If a delay is necessary at any point between peeling and dipping, the apples should be held in a weak salt brine (not over 1 percent by weight) to prevent browning.

It is desirable to keep the sulfur dioxide concentration in the tank as low as possible, in order to prevent undesirable taste in the ultimate product; however, it is also necessary to keep the concentration high enough to insure retention of the light, normal color in the slices. Another important factor is the holding time between dipping and freezing, which must be long enough to insure complete penetration of sulfur dioxide throughout the slices before they are completely frozen. Penetration is stopped by freezing and is not resumed quickly enough on defrosting to prevent browning in the areas not penetrated. Under conditions where the temperature of the apples and of the solution is in the range of 60° to 80° F. (common in late summer and early fall) and the slices are not frozen for 8 hours or more after treatment and packaging, a dip in a solution containing 2,000 parts per million (0.2 percent) of sulfur dioxide has proved sufficient for California-grown Gravenstein and Newtown Pippin varieties. The penetration is somewhat slower when the fruit and solution are colder; a longer delay is then necessary to insure complete penetration.

Since 2,000 p.p.m. of SO_2 is the minimum safe concentration in the bath for a 1-minute dip and the concentration is continually lessened by absorption into the fruit, it is important to maintain a concentration of from 2,000 to 3,000 p.p.m. of SO_2 (0.2 to 0.3 percent).

A delay of at least 8 hours or overnight should be allowed between dipping and freezing, regardless of the concentration of SO_2, when a bisulfite solution is used for dipping; however, when sulfurous acid is used a delay is not necessary because the rate of penetration is much more rapid. If there is any question about the thoroughness of the penetration it is advisable to test the slices frequently to determine whether the penetration is complete before the packaged slices are put in the freezer. This can be done easily by cutting the slices in two and putting a few drops of a 1-percent catechol solution on the cut surfaces. If the penetration is incomplete, the "unsulfured" area will turn dark brown or black in a short time--a half hour or less. It is best to make a fresh solution of catechol every few days and test it on the cut surface of an untreated apple before it is used. A 1-percent solution can be made by dissolving 2-1/2 level teaspoons of the powdered catechol in a half pint of water. Catechol is produced by manufacturers of organic chemicals and can be obtained from most chemical supply houses.

The concentrations mentioned above have proved adequate for apples sliced in twelfths. Larger segments will require a longer delay between dipping and freezing, and if the slices are much larger a more concentrated SO_2 solution will be required. The slices should be as uniform as possible so that the penetration will be complete in all slices at about the same time.

After dipping, the slices are drained and packaged. Sugar need not be added unless it is desired by the trade. The addition of sugar does not aid in preserving the color of fruit treated with the bisulfite solution. On the contrary, there is some indication that sugar tends to retard the penetration of the bisulfite.

Preparing the Sodium Bisulfite Dipping Bath

The sodium bisulfite solution can be made by introducing definite proportions of liquid sulfur dioxide and sodium hydroxide (lye) into water or by dissolving sodium bisulfite powder in water. When sulfur dioxide is dissolved in water it combines with the water to form sulfurous acid. Sulfurous acid and sodium hydroxide (lye) solution in the right proportions combine and the result is sodium bisulfite solution. If too much lye is introduced, sodium sulfite or a combination of sodium sulfite and sodium hydroxide solution will be obtained. Such a solution is alkaline and will have a very undesirable effect on the fruit.

If liquid sulfur dioxide and lye are to be used, a perforated copper tube is fastened to the bottom of the vat with copper nails for the introduction of the former. One end of the tube, without perforations above the bath level, projects from the vat a sufficient distance so that the cylinder of liquid SO_2 can be attached. The vat is filled with water, preferably between 60° and 80° F., to a depth of 12 to 14 inches. Eight ounces of sodium hydroxide (ordinary household lye) dissolved in the water and 13-1/2 ounces of liquid sulfur dioxide admitted through the copper tube for every 100 gallons of water in the vat will make a bath containing approximately 1,000 p.p.m. of SO_2. Since a bath having a concentration of 2,000 to 3,000 p.p.m. of SO_2 is desired for apples, two to three times these amounts are required for every 100 gallons or 13-1/3 cubic feet of water.

The sodium hydroxide content of ordinary household lye is approximately 95 percent, and that of commercial caustic soda flakes about 76 percent. The quantity of lye used should be increased in inverse ratio to the amount of sodium hydroxide (caustic soda) it contains. For example, for every 100 gallons of sodium bisulfite solution containing 3,000 p.p.m. of SO_2, 1-1/2 pounds of lye and 2 pounds and 8 ounces of liquid SO_2 are required. This is based on the assumption that the lye is 95 to 100 percent sodium hydroxide; if commercial caustic soda flakes containing 76 percent of sodium hydroxide are used instead of lye, the quantity should be 2 pounds.

Care should be taken not to admit the sulfur dioxide fast enough to cause bubbles to rise to the surface. The calculated quantity of sulfur dioxide can be measured either by weighing the cylinder and setting the scale so that it will trip when the right amount has been delivered to the bath, or by measuring volumetrically. A device can be made that consists of an iron tank equipped

with a glass liquid-level gage calibrated in pounds of SO_2 in such a position as to show the amount of liquid SO_2 in the tank when it is in a vertical position. In such a device the level of clear liquid in the gage is lowered as the SO_2 is admitted to the bath, and the delivery of gas is stopped when the liquid-level indicates that the estimated amount has been withdrawn.

After the estimated quantities of chemicals have been added, the solution must be tested. Testing is done when it is certain that the solution is thoroughly mixed. A little of the solution is placed in a test tube or glass and a few drops of methyl red indicator (1-percent solution in alcohol) are added. If the solution turns red, the bath is acid and is ready for use. If, however, the solution turns yellow, the bath is alkaline, which means that either too much lye or not enough SO_2 was added. More SO_2 should then be added until the bath gives an acid reaction, as indicated by the red color when methyl red is added to another test sample. The addition of too much lye can be detected by testing the solution by the method described below. Brom-cresol green indicator and a spot plate can be used instead of the methyl red if desired. A yellowish green to green color indicates the acid range, whereas a definite blue indicates that the solution is too alkaline. If the strength of the bath exceeds 3,000 p.p.m. of SO_2, it should be diluted with water to within the proper range.

If sodium bisulfite powder is used, 23 ounces will be required for every 100 gallons of water to give a concentration of 1,000 p.p.m. (or 0.1 percent) of SO_2; 4 pounds and 5 ounces will be required for 3,000 p.p.m.

Testing and Maintaining the Sodium Bisulfite Bath

The SO_2 in the bath will diminish through use. In order to keep the strength within the range required, a sample should be tested with a standard iodine solution several times a day to determine the strength and the amount of SO_2 or sodium bisulfite powder that must be added to bring it up to the desired concentration.

The following equipment, which can be obtained from chemical supply houses, is required:

- One 25- or 50-ml. burette with suitable support
- One 10-ml. pipette
- Two 125-ml. Erlenmeyer flasks
- Iodine solution (0.1 normal)
- Starch indicator, made by boiling potato starch (1 percent in water) until it becomes translucent

Fill the clean dry burette, which is supported by a ring stand or wall bracket, with the iodine solution up to the zero mark. The tip of the burette below the stopcock must also be full, and can be filled by turning the stopcock and letting a little run through. Read and record the volume of iodine solution in the burette at the beginning of each test. The curved surface of the solution in the burette is called a meniscus; the reading is taken from the center of the meniscus, rather than from the sides. Now take a sample from the dipping bath in a clean dry glass or beaker. Suck a portion into the clean dry pipette to a level above the 10-ml. mark on the upper stem of the pipette and quickly

cover the top of the pipette with the index finger. Then slightly loosen the finger while holding the pipette over the beaker until the center of the meniscus reaches the 10-ml. mark on the upper stem of the pipette and again increase the pressure of the finger to hold the solution at the mark. Now let the contents of the pipette drain into a clean 125-ml. Erlenmeyer flask and add approximately 50 ml. of water and a few drops of starch indicator.

Next add the iodine solution from the burette to the sample of bath solution in the flask until the latter solution changes to a permanent blue color. Add the iodine solution slowly and at the same time shake the flask with a gentle rotary motion. Reduce the rate to one drop at a time near the end, until the entire volume of bath solution becomes blue and retains the color. Care must be taken not to add more iodine solution than is required to give the first permanent blue color. A few preliminary trials may be necessary.

Now read the burette again. Subtracting the second burette reading from the first gives the number of milliliters of iodine used. Each milliliter of the 0.1 N iodine used represents 320 p.p.m. of SO_2 in the bath. For example, if the burette reading indicates that 8.9 ml. of iodine solution has been used, the strength of the bath is 320 x 8.9 = 2848 p.p.m. of SO_2, which is within the desired range of 2,000 to 3,000 p.p.m. However, if only 5.4 ml. of iodine has been used, the concentration of SO_2 in the bath is 320 x 5.4 = 1728 p.p.m. of SO_2. It is necessary then to add 1 pound and 1 ounce of liquid sulfur dioxide, or 1 pound and 13 ounces of sodium bisulfite, per 100 gallons of bath to bring the strength up to 3,000 p.p.m. of SO_2. To avoid the necessity of calculating the strength of the bath and the amount of SO_2 or bisulfite to be added each time, the accompanying table (Table 1) has been prepared.

When the bath becomes clouded by fruit particles, the vat should be emptied and rinsed, and a new solution should be prepared. It is good practice to prepare a new solution daily.

Scalding in Steam

Scalding the apple slices in live steam also prevents discoloration when the fruit is stored at zero or below. It has one disadvantage, however, that has not as yet been overcome; that is loss of water and soluble material, such as sugar, acid, and flavoring substances. The total weight lost may be as much as 20 percent. If spray cooling is used, the slices may absorb enough water to return to their original weight, but a portion of the soluble material, which contributes to the flavor and the nutritional value of the fruit, has been lost. The net result of steam scalding and spray cooling, then, is dilution of the fruit.

It is not well to overscald, because the slices become soft and lose weight. Adequate scalding can be determined by preliminary tests, under the conditions of the regular operation. One can make these tests easily by running a series of small lots, beginning with a 1-minute scald and increasing the succeeding ones by 20 to 30 seconds each. As soon as the slices are cool they should be cut in two. If the scald was not sufficient, the underheated portion of the slice will quickly turn brown. Ten or 20 seconds can be added to the minimum time, in order to provide a margin of safety. Uniformity in the size of the

slices is very important if they are scalded, because the heating must be sufficient to penetrate the largest slice. If there is much difference in sizes of the slices the smaller ones will be excessively softened. After the slices are cool, they can be packaged and frozen without delay. Sugar is not required.

Packaging and Storage

Since the apple slices will tend to settle after they are packed, especially if they are hauled some distance before they are frozen, the packages should be rigid enough to support the weight required in stacking. They should also be tight enough to prevent excessive loss in weight through evaporation in storage.

Freezing and storage temperatures should be maintained at 0° F. or below.

Table 1. Amounts of liquid sulfur dioxide (SO_2) or sodium bisulfite powder (per 100 gallons of water) required to increase the concentration of SO_2 in a dipping bath to 3,000 parts per million (p.p.m.), based on test with 0.1 N (one-tenth normal) iodine and 10 milliliters of dipping bath.

Iodine (0.1N) required to give blue color	Concentration of SO_2	Amount of one or the other required to make 3000 p.p.m. SO_2: Liquid SO_2	Sodium bisulfite
Ml.	P.p.m.	Lb. & Oz.	Lb. & Oz.
0.0	0.0	2 - 8	4 - 5
0.1	32	2 - 8	4 - 4
0.2	64	2 - 8	4 - 3
0.3	96	2 - 7	4 - 2
0.4	128	2 - 7	4 - 2
0.5	160	2 - 6	4 - 1
0.6	192	2 - 6	4 - 0
0.7	224	2 - 5	3 - 15
0.8	256	2 - 5	3 - 15
0.9	288	2 - 5	3 - 14
1.0	320	2 - 4	3 - 13
1.1	352	2 - 4	3 - 13
1.2	384	2 - 3	3 - 12
1.3	416	2 - 3	3 - 11
1.4	448	2 - 2	3 - 10
1.5	480	2 - 2	3 - 10
1.6	512	2 - 2	3 - 9
1.7	544	2 - 1	3 - 8
1.8	576	2 - 1	3 - 7
1.9	608	2 - 0	3 - 7
2.0	640	2 - 0	3 - 6
2.1	672	1 - 15	3 - 5
2.2	704	1 - 15	3 - 4
2.3	736	1 - 15	3 - 4
2.4	768	1 - 14	3 - 3
2.5	800	1 - 14	3 - 2
2.6	832	1 - 13	3 - 1
2.7	864	1 - 13	3 - 1
2.8	896	1 - 12	3 - 0
2.9	928	1 - 12	2 - 15
3.0	960	1 - 11	2 - 14
3.1	992	1 - 11	2 - 14
3.2	1024	1 - 11	2 - 13
3.3	1056	1 - 10	2 - 12
3.4	1088	1 - 10	2 - 12
3.5	1120	1 - 9	2 - 11
3.6	1152	1 - 9	2 - 10
3.7	1184	1 - 8	2 - 9
3.8	1216	1 - 8	2 - 9
3.9	1248	1 - 8	2 - 8
4.0	1280	1 - 7	2 - 7
4.1	1312	1 - 7	2 - 6
4.2	1344	1 - 6	2 - 6
4.3	1376	1 - 6	2 - 5
4.4	1408	1 - 5	2 - 4
4.5	1440	1 - 5	2 - 3
4.6	1472	1 - 5	2 - 3
4.7	1504	1 - 4	2 - 2
4.8	1536	1 - 4	2 - 1
4.9	1568	1 - 3	2 - 1
5.0	1600	1 - 3	2 - 0
5.1	1632	1 - 2	1 - 15
5.2	1664	1 - 2	1 - 14
5.3	1696	1 - 2	1 - 14

Table 1 - (concluded)

Ml.	P.p.m.	Lb. & Oz.	Lb. & Oz.
5.4	1728	1 - 1	1 - 13
5.5	1760	1 - 1	1 - 13
5.6	1792	1 - 0	1 - 12
5.7	1824	1 - 0	1 - 11
5.8	1856	15	1 - 10
5.9	1888	15	1 - 10
6.0	1920	15	1 - 9
6.1	1952	14	1 - 8
6.2	1984	14	1 - 8
6.3	2016	13	1 - 8
6.4	2048	13	1 - 6
6.5	2080	12	1 - 5
6.6	2112	12	1 - 5
6.7	2144	12	1 - 4
6.8	2176	11	1 - 3
6.9	2208	11	1 - 2
7.0	2240	10	1 - 1
7.1	2272	10	1 - 0
7.2	2304	9	1 - 0
7.3	2336	9	1 - 0
7.4	2368	9	15
7.5	2400	8	14
7.6	2432	8	13
7.7	2464	8	13
7.8	2496	7	12
7.9	2528	7	11
8.0	2560	6	10
8.1	2592	6	10
8.2	2624	5	9
8.3	2656	5	8
8.4	2688	5	8
8.5	2720	4	7
8.6	2752	4	6
8.7	2784	3	5
8.8	2816	3	5
8.9	2848	2	4
9.0	2880	2	3
9.1	2912	2	3
9.2	2944	1	2
9.3	2976	1	1
9.4	3008	None	None